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Laboratories Needed to Support Long-Term Exploratory Research in the U.S. Environmental Protection Agency A Report to the President and the Congress, March 31, 1978

Environmental Protection Agency, Washington, D.C. Off. of R & D

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Laboratories Needed to Support Long-Term Research in EPA

A Report to The President and The Congress

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16. ABSTRACT

This report examines alternative laboratory approaches by which EPA could conduct long-term environmental research. The report was prepared in response to a Congressional request contained in Sec. 6(b) of the Environmental Protection Agency's Research and Development Act of 1978. In order to prepare the report, over 100 scientists and managers in twenty (20) Agencies and Laboratories were interviewed and numerous people within EPA were contacted. The Science Advisory Board of EPA participated in all phases of the reports preparation.

Four subject areas are treated in the report. (1) The History of EPA - - reviews how EPA's present laboratories were formed, discusses conceptually how the R&D process flows within EPA and presents evidence to indicate that long-term "Exploratory" research is being conducted by EPA. (2) Areas Needing Enhanced Exploratory Research - - presents a brief review of the eleven research areas which are identified as representative of those which could benefit from enhanced long-term support. (3) Mechanisms Used by Other Agencies - - discusses the advantages and disadvantages of using individual grants and contracts, Federal Contract Research Centers, University or other private centers, and Federal Laboratories for conducting long-term research, (4) The options for conducting long-term Exploratory activities within EPA are discussed.

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LABORATORIES NEEDED TO SUPPORT LONG-TERM EXPLORATORY RESEARCH IN THE U.S. ENVIRONMENTAL PROTECTION AGENCY

A Report to the President
and the Congress
March 31, 1978

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

5 APR 1978

THE ADMINISTRATOR

The President

Speaker of the House of Representatives

President of the Senate

Dear Sirs:

In accordance with Section 6(b) of Public Law 95-155, the Environmental Research, Development and Demonstration Act of 1978, I herewith submit a report on laboratories needed to support long term research in the Environmental Protection Agency. The report examines alternative approaches for conducting long term environmental research and presents eight findings and recommendations. Strengthening our long term activities is an important part of our overall research strategy in EPA and I endorse the recommendations contained herein.

Sincerely yours,

Douglas M. Costle

Enclosure

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1. SUMMARY

This report examines alternative laboratory approaches by which the U.S. Environmental Protection Agency (EPA) could conduct long-term environmental research. The report was prepared in response to a congressional request contained in Public Law 95-155 Sec. 6(b) of EPA's Research and Development Act of 1978. To prepare the report, more than 100 scientists and managers in 20 agencies and laboratories were interviewed, and numerous persons within EPA were contacted. The Science Advisory Board of EPA participated in all phases of report preparation.

Four subject areas are treated in the report. The first area is EPA history which reviews how present laboratories were formed, discusses the research and development (R&D) within the Agency, and presents evidence that long-term exploratory research is being conducted by EPA. The second subject deals with areas that need enhanced exploratory research and presents a brief review of 11 representative research areas that could benefit from enhanced long-term support. The third subject area consists of mechanisms used by other agencies. Advantages and disadvantages are discussed of four mechanisms for conducting long-term research--individual grants and contracts, Federal contract research centers, university or other private centers, and Federal laboratories. The fourth and final topic discusses options for conducting long-term exploratory activities within EPA.

The report presents eight findings and recommendations. Each is aimed at improving the mechanisms and climate for conducting long-term exploratory research in EPA.

2. FINDINGS AND RECOMMENDATIONS

1. Finding: Contrary to some perceptions, exploratory (long-term) research is an ongoing, important component of EPA's current research program.

Exploratory research, however, is not a sufficiently visible component of EPA's present R&D program. Based on definitions contained within the report and other criteria used by EPA laboratory director's, approximately 30% of the FY-1977 base (non-energy) R&D budget was estimated to be in the exploratory area.

Recommendation: Ongoing exploratory research should be continued and budgeted as an identifiable program. An office of exploratory research should be established to serve as a visible focal point for coordinating such activities and for managing basic and anticipatory research activities. Responsibility for implementing exploratory activities should rest primarily with existing EPA research and development laboratories.

2. Finding: The nature of exploratory research is such that it must be integrally linked to applied research efforts at the laboratory level. At all the institutions visited, it was noted that the co-existence of exploratory and applied activities in one laboratory strengthened and stimulated both types of programs.

Recommendation: Exploratory research activities should generally be conducted by institutions that can optimize the link between exploratory and applied programs. Exploratory programs should not be geographically or intellectually isolated.

3. Finding: Research gaps are present within EPA's exploratory activities. (Section 6 presents a representative list of research areas in EPA that would benefit from enhanced support for exploratory activities.) EPA's activities, however, represent less than one-fifth of the total Federal R&D expenditures for the environment and natural resources. The fraction of long-term research activities conducted by agencies other than EPA is presently unknown. Additionally, there are few mechanisms which can address all the needs for coordination of long-term R&D between EPA and other agencies and laboratories.

Recommendation: Both intramural and extramural exploratory research should be expanded selectively to complement existing EPA and other Federal activities. Expansions should take place only after examining opportunities for internally shifting resources to exploratory activities. An examination of exploratory R&D across the Federal government should be undertaken and the R&D pertinent to EPA problems should be identified. Exploratory research

directed at problems which may eventually require regulatory actions should have better coordination. EPA will have to develop mechanisms to match its specific needs. Mechanisms such as the Interagency Regulatory Liaison Group and the use of the lead agency concept in conjunction with pass-through funding, should be increasingly utilized.

Other elements for improved coordination should include:

1) Broad annual program planning and accomplishment meetings for all related Federal activities.

2) Program planning meetings dedicated to specific research areas between pertinent Federal agency managers.

3) A series of scientific workshops by all EPA laboratories and extramural centers on specific research areas. Workshop funds should be built into the budget of each laboratory and center.

4. Finding: Many of EPA's intramural research laboratories have unique talents and facilities and have received peer recognition for their exploratory research contributions. Often these activities have not received sufficient recognition within the Agency since good performance was often equated with the ability to provide short-term solutions for regulatory purposes.

Recommendations: The use of personnel exchanges, sabbaticals, and other mechanisms should be encouraged as a means of assuring vitality to exploratory projects, but only when not detrimental to long-term activities. Internal scientists should be encouraged to publish in scientific and technical journals on a regular basis. Mechanisms to reward outstanding achievements by individual scientists should be developed.

5. Finding: The nature of exploratory research is such that it is strengthened and enhanced by a critical scientific and technical review process.

Recommendation: A peer review process is particularly important for this type of research. A peer review process for ongoing activities should be established throughout ORD for both intramural and extramural exploratory research activities.

6. Finding: Exploratory research problems are diverse and require a wide variety of talents. Many sources of such expertise exist throughout the country in the form of Federal laboratories, university centers, Federal contract centers, and other institutions. These sources can be utilized along with internal EPA laboratories to fill research gaps and to conduct an expanded exploratory research activity.

Recommendation: In the near term, EPA should draw upon and utilize existing institutional resources as one method of filling research gaps. Approximately five to ten centers of expertise should be supported primarily at existing institutions with specialized expertise. New centers should be established only when unique circumstances are present. Approximately, $500,000 to $1 million will be required annually to support each center. A large Federal Contract Research Center for long-term research should not be established solely to support EPA activities at this time. Such a center would delay opportunities to utilize existing centers particularly those in the Department of Energy. No new legislation would be required to implement this recommendation.

7. Finding: This study has concentrated on activities pertinent to EPA's mission. However, man is exposed to harmful substances through many sources --the natural environment, the work place, food and other consumables. It is apparent that the need to assess total exposure from all sources is expanding rapidly.

Recommendation: In the long-term, activities may be needed to address a broader and expanded number of environmental, occupational, and consumer problems on an integrated basis. Activities of this type may require a research capability beyond that of existing institutions. A new institutional mechanism significantly larger than those required solely for EPA's mission may be necessary in the future. New relationships with private sector research laboratories may also need to be explored. These trends should be monitored and associated research needs documented. Further consideration should be given to a new and expanded institutional mechanism at a later date.

8. Finding: Exploratory research requires a stable fiscal and managerial atmosphere to be productive.

Recommendation: The Assistant Administrator for R&D in consultation with the Administrator and other Agency officials should define the resource level for exploratory research within the ZBB process. Stable funding should be provided to assure research continuity over long periods. Competition for resources should occur within the exploratory research category.

3. INTRODUCTION

EPA was established to protect the environment and the American public against possible threats posed by physical, chemical, and biological agents. To pursue this mission, EPA (1) establishes criteria, standards, and guidelines to control environmental pollutants; (2) takes enforcement actions to ensure compliance with the Agency's regulatory actions; and (3) maintains monitoring programs to assess changes in pollution levels and emissions over time. In addition, the Agency provides support for municipal treatment facilities, and for State and other environmental progams. A significant input to all major Agency decisionmaking in these areas is the quantity and quality of its scientific and technical information. Congress has recognized this need for information and the important link between research and regulatory functions by authorizing EPA to conduct Research and Development through the 11 different acts. The Office of Research and Development (ORD) is the EPA unit specifically charged with conducting most of the Agency's research under these legislative mandates.

In carrying out its responsibilities, ORD has recognized a need to balance near-term research objectives in support of regulatory and operational programs with longer-term objectives to stimulate advances in the environmental sciences. From its inception, however, EPA has been driven by legislation to meet short-term regulatory deadlines. These regulatory responsibilities along with limited resources have created an atmosphere that requires, a significant portion of the R&D program to be oriented toward short-term regulatory problems. Long-term activities, though implicitly considered important, have not received sufficient recognition. This problem has been identified in two different studies: one by the National Academy of Sciences (NAS) [see Section 9, Bibliography, Item number 18] and the other by Congress Office of Technology Assessment (OTA) [see Section 9, Bibliography, Item number 19].

The Senate Committee on Environmental and Public Works, which shares these concerns, included in the FY 1978 Research Development Authorization Act a requirement for EPA to report to the President and the Congress concerning the desirability and feasibility of establishing a national environmental laboratory or system of laboratories to assume or supplement long term environmental research. Specific recommendations are requested on:

- types of research to be carried out by such laboratories;
- coordination and integration of research to be conducted by such laboratories with research conducted by existing Federal or other research labs;

- methods for assuring continuous long-range funding; and
- other administrative or legislative actions necessary for establishing such a laboratory.

This report has been prepared in direct response to this Congressional request.

4. STUDY OBJECTIVES AND APPROACH

The major objective of this study is to examine the need and feasibility of establishing a single laboratory or network of laboratories for conducting long-term or exploratory environmental research. For the purposes of this study, a laboratory or system of laboratories was interpreted to include (1) development of in-house expertise within ORD's existing laboratory system; (2) creation of new government owned, contractor operated research centers (GOCO) or utilization of existing ones; (3) development of university centers of expertise or utilization of existing ones; and (4) use of individual grants and contracts specifically aimed at conducting exploratory environmental research.

This study aims to determine which of these mechanisms is most appropriate for conducting exploratory environmental research in EPA. Such a mechanism should be tailored to the ongoing and future exploratory environmental research efforts in the Agency. It should also be a mechanism that can function within the framework of the Agency's organizational structure without violating any legislative or institutional constraints placed on EPA. As a result, the following tasks were undertaken:

- Quantification of the exploratory research currently being conducted in ORD and identification of gaps where future ORD exploratory research should focus.

- Analysis of the advantages and disadvantages of various mechanisms for conducting exploratory research.

- Recommendations as to the appropriate mechanisms for EPA in light of current and future exploratory research activities and legislative, organizational, and institutional considerations.

To prepare this study, the Acting Assistant Administrator for Research and Development, Dr. Stephan Gage, formed a task force of EPA scientists and managers in October 1977. Members of the task force were selected because of their widely varied backgrounds. They included persons with experience in EPA, its predecessor agencies, other agencies such as NASA and AEC, and industry and university research programs. Selections were also based on experience with problems in a number of different environmental media and in several scientific disciplines. One member of the task force was also a staff member of EPA's Science Advisory Board. The task force used interviews and questionnaires as the principal devices to gather data in the support of the above tasks.

For the first task, (quantification of current EPA exploratory research), working definitions of basic, anticipatory, and exploratory research were developed in consultation with EPA's Science Advisory Board. These definitions were incorporated into a questionnaire forwarded to ORD's 15 laboratory directors. The questionnaire specifically requested each laboratory director to make a major division of his laboratories activities into either exploratory research or regulatory/operational support R&D. Within each major category, a designation concerning the funds dedicated to inhouse and extramural efforts was also requested. These data were later used as one measure of the applicability of each mechanism available to EPA for the conducting of exploratory research and development. Additional questions, including a request to identify research gaps, are presented in Figure 1.

For the second task analyzing the advantages and disadvantages of current mechanisms used (by the government for exploratory research), in-depth interviews were conducted with key officials in relevant government agencies, private research institutions, and universities. These interviews focused specifically on (1) determining examples of successful long-range research efforts, (2) determining the management structure associated with each successful mechanism, (3) estimating the level of resources required to sustain each mechanism, and (4) determining the potential applicability of each laboratory system to the exploratory research efforts of EPA.

Achievement of the first two tasks laid the foundation for the third (recommendations on exploratory research). It was recognized that any recommendation must reflect a consideration of EPA's operational constraints. The senior staff in EPA headquarters and ORD laboratories were thus interviewed to identify organizational, institutional, or legislative constraints that could conceivably affect the viability of candidate exploratory research mechanisms.

The results from this round of interviews and the first two tasks were then consolidated to arrive at the findings and recommendations presented in this report.

Finally, it must be noted that assembling quantitative data for this type of study is extremely difficult. Hence the findings presented in the report flow primarily from subjective judgments rather than vigorous quantitative analyses. Also, the short time period allowed for the report precluded in-depth examinations of the scientific programs conducted by the many agencies and institutions contacted during the study. No judgments were made about the quality of the science associated with each institution.

1. What is the existing research mix within your laboratory, i.e., between in-house (long-term, fundamental and anticipatory research and direct research in support of regulations) and extramural (long-term, fundamental, and anticipatory research and direct research in support of regulations) research?

FY 1977 ($ and MY)

In-house Total	Extramural Total
a. Long-term/Fundamental/ Anticipatory Research	a. Long-term/Fundamental/ Anticipatory Research
b. Research in Direct Support of Regulations	b. Research in Direct Support of Regulations

2. What are the essential ingredients that should be considered in developing a long-range fundamental research activity?

3. What are the unique circumstances at your lab that would drive you to pick a particular extramural laboratory system and corresponding management approach?

4. If you were directing ORD, what type of management system would you utilize in a fundamental research program in planning and allocating resources, reviewing proposals, and monitoring projects?

5. What environmental long-term fundamental research gaps exist that should be addressed by ORD's existing labs or supplemented by an expanded national laboratory system, i.e., Federal Control Research Center's University Centers, etc.?

Figure 1. Questionnaire for ORD Lab Directors

5. RESEARCH AND DEVELOPMENT IN EPA

History

EPA was created in December 1970 by Executive Order No 3. This order assigned to the new agency the major environmental regulatory components of five separate Federal agencies. These components included 30 laboratories and field sites, many of which formed the nucleus of the research and development organization of the new agency. Typically, the staffing and facilities of these laboratories were structured to provide the scientific and technical support required for implementation of specific, single-media-oriented environmental laws. There were very few intermedia activities, and the long-term and anticipatory research was not a significant ingredient of the program.

In the past 7 years, ORD has made a continuum of changes in attempting to integrate the diverse elements of previous groups into a balanced organization to support the Agency in implementing existing laws and to provide research to guide the development and formulation of new environmental policies, legislative initiatives, and regulatory actions. From its inception ORD recognized that its research functions should include a broad responsibility to conduct research programs of an exploratory and long term nature. But, the legislation of the early seventies created significant demands for scientific and technical information to support development of regulations and enforcement actions. Programs directed at filling short term regulatory needs clearly required priority during these years.

Today, ORD is made up of a headquarters staff and 15 laboratories. (Appendix A provides a description of the present ORD). The director of each laboratory reports to the Assistant Administrator for Research and Development through one of the four following Deputy Assistant Administrators' Offices:

-Health and Ecological Effects
-Air, Land, and Water Use
-Energy, Minerals, and Industry
-Monitoring and Technical Support

ORD includes approximately 1,700 permanent personnel positions and administers a budget of approximately $320 million per year. The staff includes some 60 different professional disciplines. Program resources, as described later in this chapter, are balanced between short-term regulatory requirements and longer-term needs in proportion to the primary functions of the above offices.

In fiscal 1979, this program will represent only one-fifth of the Federal efforts on basic and applied environmental and natural resources research. Special Analyses, Budget of the United States Government FY-79 there is growing recognition that EPA must utilize the research expertise and results available in other agencies and must develop mechanisms to accomplish this need.

EPA has taken this charge seriously and has signed numerous interagency agreements aimed at utilizing the capabilities of other agencies. One of the most successful experiments to date in interagency coordination has been the Federal Interagency Energy/Environmental Research and Development Program. This program, which was launched in 1974, has involved 17 Federal agencies cooperating under EPA leadership. Funding for the program has averaged about $100 million per year from fiscal 1975 on. Another more recent example is the cooperative effort of Administrator Costle, and the heads of the Occupational Safety and Health Administration, the Food and Drug Administration, and the Consumer Product Safety Commission. Under their leadership, an interagency regulatory liaison group was formed to maximize the coordination of regulatory and other activities within each agency. This group has already begun sharing information on ongoing research projects, initiating joint research planning, and acting to assure the transfer of research results. In the future, interagency cooperation of this type will continue to represent an important responsibility of EPA.

The Research and Development Process

The language adopted in the Environmental Research Development and Demonstration Act of 1978 indicates that Congress recognized that all EPA research and development programs have some inherent long-term components. In fact, research and development activities, whether in EPA or other institutions are all on a continuum wherein various stages cross-fertilize and link with one another.

In the Defense Department, these stages are known as research, development, testing and evaluation (RDT&E). In other agencies, the terms, "basic", "applied", and "development activities" are utilized. Regardless of the terminology, it is important to recognize that these various research and development activities cannot be arbitrarily separated, but must be closely tied to each other. It is rare that basic research, beginning in isolation, produces results that applied R&D activities utilize in a sequential fashion. More often, the need for advances in basic understanding is perceived by applied programs, and this need is translated into increased basic research activities. The flow of ideas and results is an iterative process. It involves the amalgamation of new facts with old ones and a resynthesizing of the whole. At the laboratory scientist level, the applicability and ultimate use of much basic research may at times remain obscure. But there is always the possibility that any discovery may become the life blood of applied mission programs.

In EPA, R&D activities are grouped into three categories, which are defined as follows:

a. Exploratory R&D: Research conducted primarily to develop fundamental knowledge applicable to the solution of currently intractable problems or scientific questions; or, research aimed at identifying or understanding environmental problems that are on the horizon but for which no specific regulatory activity is currently scheduled.

b. Regulatory/operational support R&D: Research done in response to identified program or regional office operation requirements; or, research designed to enhance or confirm agency, program, or regional objectives but not immediately required in support of scheduled regulatory actions. This type of R&D also includes technical assistance support services in response to ad hoc needs or special requirements that cannot be planned through the normal planning cycle.

c. Assigned mission R&D: Research performed in response to missions specifically assigned to EPA by the White House, Congress, or Office of Management and Budget beyond the general requirements of the Agency's enabling legislation. (Examples include the Interagency Energy/Environment Program and the Biological and Climate Effects of Radiation Program—BACER.)

In this context, the principal components of exploratory research are defined to include basic environmental, anticipatory, and applied research.

Basic Environmental Research. Basic environmental research is conducted primarily to develop new environmental knowledge and principles. It is not usually directed at a specific environmental problem; rather, it seeks new laws and understanding that can be used to define and predict the relationship between environmental factors and physical, chemical, and biological phenomena. Basic environmental research is not usually conducted in support of a specific regulatory action, but it does serve as the basis of scientific knowledge to be employed by applied research programs that support the Agency's mission and as a source of information for anticipatory research activities. Basic environmental research objectives may not always be well-defined, and the applications may be difficult to predict. The activities usually take considerable time, but the specific length of time needed for a project is difficult to predict. (In this context, basic environmental research does not include research that is directed solely toward advancing the state of knowledge in a specific discipline such as mathematics, but it does include research in a single discipline that is relevant to the mission of the Agency.)

Anticipatory Research. Anticipatory research identifies or characterizes a problem on the horizon that may be only faintly perceived and for which no specific regulatory decision or action is planned. It is aimed at determining whether or not something should be done

to avoid a crisis, and whether a more formal research effort should be established. Anticipatory research includes the analysis of emerging industrial, agricultural, transportation, and urban trends; forecasts of significant environmental insults; and investigations of the nature and scope of environmental problems. This research may ultimately result in the establishment of a regulatory support research and development program. The time necessary to conduct this research varies but the horizon the activities are scanning will be long-term.

Applied Research (Advanced Concept Development). Applied research explores the feasibility and utility of basic research results. It extends basic results into pilot efforts to test, develop, and confirm concepts and tools under different conditions. The time frame for conducting this effort, is uncertain but more predictable than for basic research. Applied research links basic activities to applied regulatory support research and development oriented studies.

For the purposes of this report, the universe of activities corresponding to the congressional long-term program includes all exploratory research, whether it is basic, anticipatory or applied. The long-term program also includes all activities in the regulatory/operational support R&D category that require long periods of time or span a broad time horizon. A broader scientific definition of exploratory research has thus been adopted for the purposes of this study. Note that EPA's programs are not presently budgeted by these categories.

Resource Trends

A history of ORD resources for the past 7 years is shown in Table 1. Funding for core activities (except for energy related research) has remained relatively stable in recent years. The number of personnel positions has declined, but the workload has increased across ORD. Total funds per authorized position have more than doubled from fiscal 1973 to fiscal 1977. The result is a trend toward reduced intramural programs and increased extramural contract and grant activities.

Exploratory research estimates for fiscal 1977 for each major program office and associated laboratory are presented in Table 2. Exploratory resource levels were estimated by each laboratory director, based on the previously presented definitions of exploratory research and regulatory/operational support R&D. In all cases, judgments were required about the applicability of the research activities to presently planned regulatory actions, the length of time required to conduct the research, and the nature of the research. Table 2 indicates that all laboratories and all principal research offices are presently conducting some exploratory research. This effort is significant and exceeds early perceptions about the amount of exploratory research conducted by ORD. It also requires a further elaboration of how these estimates were derived.

Table 1. HISTORICAL TREND OF ORD RESOURCES

	FY-71	FY-72	FY-73	FY-74	FY-75	FY-76	FY-77	FY-78**
Total New Obligational Authority (in thousands of dollars)	01,764.0	123,437.3	129,807.1	144,320.9	282,444.2*	252,423.6	241,949.4	245,666.1
Authorized Personnel	1379	1705	1914	1814	1750	1750	1727	1729

*$134,000 Energy/Environment program added
**FY-78 Carter Budget

Table 2. FY-77 EXPLORATORY RESEARCH FUNDS BY ORD PROGRAM OFFICE AND LABORATORY (EXCLUDES ENERGY FUNDS)

	($K) Total Exploratory Research	Total $ (K)	% of Exploratory Research
Office of Monitoring and Technical Support			
EMSL - RTP	$ 1,016	$ 5,221	19%
EMSL - CINC	550	5,611	10%
EMSL - LV	1,724	9,065	19%
HQ - OTHER	—	5,169	0
TOTAL	2,740	25,067	11%
Office of Energy, Minerals and Industry			
IERL - RTP	1,320	4,426	29%
IERL - CINC	1,500	7,561	20%
HQ - OTHER	—	2,516	0
TOTAL	2,820	14,504	19%
Office of Air, Land and Water Use			
ESRL - RTP	11,642	16,946	69%
MERL - CINC	5,774	19,094	30%
ESRL - Athens	3,925	3,925	51%
ESRL - Ada	1,320	1,320	21%
HQ - OTHER	—	3,718	0
TOTAL	22,661	53,581	42%
Office of Health and Ecolgocial Effects			
HERL - RTP	9,291	22,805	40%
HERL - CINC	950	8,222	11%
HERL - Corvallis	5,271	7,706	68%
HERL - Duluth	1,550	6,162	25%
HERL - Narragansett	1,280	3,477	37%
HERL - Gulf Breeze	1,074	2,831	38%
HQ - OTHER	—	5,297	0
TOTAL	19,416	66,725	34%
Other	—	3,251	0
ORD Total	$ 47,637	152,628	31%

First, it must be recognized that the nature of the definitions was a significant factor in influencing the results of this survey. Second, as laboratory directors utilized the definitions to examine their programs, a common operational approach evolved by which the degree and definitiveness of EPA program office support became a governing criterion. Thus, the estimates presented in Table 2 were developed not only on the basis of the scientific definitions presented previously, but also on the basis of how well each laboratory could couple its programs to program and regional office needs. Finally, it must be noted that although an estimated $47 million was designated for exploratory research, in fiscal 1978 only $4.7 million actually fell in the basic environmental and anticipatory category. Thus, most resources placed in the exploratory category were advance concept development programs that ORD Laboratory Directors viewed supportive of potential long-term regulatory need but not applicable to short-term requirements.

Further examination of Table 2 indicates that the percentage of resource dedicated to exploratory efforts varies with the mission of each office and laboratory. For example, the Environmental Monitoring and Support Laboratory in Cincinnati indicated that only 10 percent of its research was exploratory because its programs are heavily oriented toward developing standard measurement methods and quality assurance programs to support the regulatory programs of the Office of Water and Hazardous Material (Effluent Guidelines, etc.). The Environmental Sciences Research Laboratory in Research Triangle Park indicated that almost 70 percent of its resources were dedicated to exploratory efforts. Again, this figure reflects the major emphasis of the laboratory, which, in this case is to develop advanced air pollution measurement methods and to conduct basic research into atmospheric transport and transformation processes. Further insights are possible by examining more closely a program that estimated that 30 percent of its resources were in the exploratory category. The Municipal Environmental Research Laboratory in Cincinnati, is representative of this type of split program. It has a Solid Waste Research Division, a Water Supply Research Division, and a Wastewater Research Division. Within this laboratory, the Wastewater Research Division examined its projects and placed the following kinds of activities within the exploratory category:

1. Studies to assess the potential reuse of municipal effluents discharged aboved water supply intakes. These studies to characterize effluents and stream water quality are coupled with other studies to determine the health impacts on populations exposed to wastewaters. These studies were conducted in advance of Agency regulations or policies on wastewater reuse.

2. Studies to examine the chemical structure of toxic substances and to determine correlations with the effectiveness of different treatment processes. (The purpose is to be able to estimate the effectiveness of a treatment process on an untested toxic substance whose chemical structure can be described.) Present regulations on publicly owned treatment works require only treatment for biological oxygen demand (BOD) and suspended solids (SS).

3. Studies of methods to control stormwater runoff. At present, EPA does not have regulations to control stormwater runoff.

These examples, though clearly not at the basic end of the research spectrum, were designated as exploratory because they matched the definition of applied research in support of advanced concepts and because they did not closely support a planned regulatory initiative. Additional examples of exploratory activities conducted in the past, often before regulatory actions were planned, are presented in Appendix B. These projects are typical of the type that allowed ORD's laboratory staff to be involved in research activities that enhanced their ability to conduct applied research or to provide technical assistance. When initiated, these projects were often not perceived to be important by program offices because the problems were long-term, multimedia, or high risk ventures.

Finally, it should be noted that often different programs are conducted within each laboratory. This is the case within the Municipal Environmental Research Laboratory, the Health Effects Research Laboratory in Research Triangle Park, and a number of other laboratories. Each program may have relatively different proportions of exploratory research and regulatory/operational support R&D. For example, Health Effects Research Laboratory's program to determine the health effects of pollutants from transportation sources conducts relatively few exploratory activities. In contrast, the environmental carcinogen program conducted by the same laboratory is almost totally anticipatory in nature. Such distinctions are masked by the data presented in Table 2, but the co-existence and intermingling of exploratory research and regulatory/operational support R&D within the same laboratory is important to the vitality of each ORD Laboratory and must be recognized.

6. AREAS NEEDING ENHANCED EXPLORATORY RESEARCH

The previous chapter documented the program areas and laboratories that are conducting exploratory research activities. This chapter highlights briefly research areas that either are not being addressed or could be enhanced by a supplemental effort. The list of potential needs is considerable, however, and the task force therefore determined that areas identified in this report should meet the following tests:

1. To be included, either (1) the research need should not be addressed by the present program, or (2) the complexity of the problem or the present level of effort should indicate that supplementary efforts are warranted.

2. The research problem should require a long-term, sustained support rather than a short, intensive burst of activity. Also, the research results should be needed to stimulate applied research activities, and the results should be basic enough to support environmental control requirements regardless of policy or organizational changes.

In adopting this approach the task force recognized that many worthy research areas would be excluded. It also recognized that the passage of time would allow new insights to be developed into areas needing enhanced efforts. The present areas that need enhanced exploratory research are as follows:

- Atmospheric processes and effects
- Chemical and physical methods of measurement
- Development of risk assessment methodologies
- Ecosystem dynamics
- Epidemiology
- Fundamental mechanisms involved in land application of wastes
- Global problems
- Groundwater research
- Integrated exposure assessments
- Pollution control processes
- Screening techniques and early indicators of toxicity
- Socio-economic research

This list should be considered representative only. New and perhaps more important needs will most certainly evolve in the future.

The list was developed on the basis of suggestions from Laboratory Directors, discussions with scientists and environmental managers in non-EPA laboratories, and interviews with other EPA personnel. In almost all areas, the actual research could be conducted through either extramural or intramural efforts. Many factors such as personnel ceilings and the availability of qualified staffs and facilities must be considered before implementation can proceed.

The sequence in which the activities are selected or implemented will depend on a number of factors, including availability of funds, presence or absence of scientific capability, guidance from the scientific community, activities of the Interagency Regulatory Liaison Group (IRLG), and the Agency's perceptions of research areas needing increased attention.

The Interagency Regulatory Liaison Group is addressing research and development collaboration, risk assessment procedures, and the development of compatible testing and epidemiology standards and guidelines. These efforts are designed to improve the usefulness of the information developed by the four agencies as well as the private sector. Close cooperation of this type is required with other pertinent agencies.

Integrated Exposure Assessments

Man is exposed to substances in the environment from multiple sources, (water, air and food, for example) that come in contact with human tissues through inhalation, ingestion, and contact with the skin. He is exposed while in his work place, home, or recreational environment. Some of the substances that effect him are manmade, and others are natural background materials. Responsible regulatory approaches must thus require that consideration be given to total exposures and body burden levels. But our ability to collect and analyze data in order to derive exposure assessments, except under unique conditions, is limited. When attempts are made to estimate past exposures, even over the last 20 years, the job becomes even more difficult and points up the need for reliable monitoring methods.

In the future, all regulatory agencies responsible for protecting man will likely require total exposure information. Such data are essential to epidemiological studies and ultimately to an integrated regulatory approach. The development of techniques and methods to obtain and analyze exposure data will require a sustained effort over a long period of time. Multidisciplinary teams of biologists, toxicologists, industrial engineers, and mathematicians will be required to develop and test exposure assessment approaches.

Epidemiology

One method of evaluating human health risks is through epidemiological studies. Such studies are inherently long-term, require the use of good exposure data, and must consider many variables at one time. Recently,

data gathering and statistical approaches to manipulate data have become increasingly complex to assure that scientifically valid experiments are conducted. Yet when regulatory decisions must be made, good epidemiological information is not always available.

EPA uses epidemiological studies along with chemical and toxicological tests to determine human health risks. The spectrum of epidemiological research needs within this area includes (1) the development of improved methodologies, (2) the systematic collection and storage of demographic, genetic, and body burden data bases, (3) the improvement of statistical techniques, (4) the conduct of prospective epidemiological studies to explore potential correlations between environmental pollutants and diseases such as emphysema and hypertension, (5) and the conduct of routine studies with proven methods in support of regulations. EPA's present activities in this area emphasize the need to develop information for regulatory purposes. Relatively few studies are directed at improving methodologies.

Closely associated with this research need is a requirement for trained personnel to conduct research. A study by the Department of Health Education and Welfare, "Human Health and the Environment--Some Research Needs," (see Section 9, Bibliography, Item number 8) indicated that epidemiology training was primarily at the post-doctoral level. The output of scientists was small and varied between 3 and 10 during the period 1966 to 1975. The output in 1975-76 increased to 20. This study noted that though the demand for epidemiologists could not be quantified, demand substantially exceeded the supply and would increase in the future with new laws and industrial research activities. In the near term, additional research support will further stress this manpower shortage; but in the long run, additional research will complement training activities to assure that the national need for this scientist is met.

Socio-Economic Research

The need for socio-economic research that is aimed at environmental control programs has been recognized within EPA, the academic community, and industry, as illustrated by a recent report by the National Research Council (see Section 9, Bibliography, Item number 6). There has been less agreement about what should constitute the nature of such a program. Recent activities have been focused on a limited program to improve methodologies for estimating the benefits of pollution control and to develop incentives to supplement regulatory actions. This approach, undertaken because of limited and unstable resources, does not provide for comprehensive analyses of many important problems or for the continuing development of methodologies and information to support a national environmental protection program.

Within this area, several research needs (in addition to further development of benefits/cost methodologies) appear to warrant a continuing commitment. These needs include (1) the continuing development and evaluation of improved incentives, including economic tools for pollution control decisionmaking, (2) development and evaluation of actual field-level testing of alternative implementation approaches, and (3) development of methods for

coupling economic approaches with other research approaches (epidemiology, for example). Furthermore, a great deal more research needs to be conducted on the mechanisms used by the private sector to respond to government regulation. An understanding of typical response patterns would enable EPA to make more precise estimates of the anticipated economic impact of proposed regulations. It might also enable the agency to formulate regulations in ways that would minimize adverse economic effects. For example, it could be hypothesized that EPA consistently overestimates the anticipated private sector costs of complying with regulations because it underestimates the ability of the private sector to adjust to regulatory actions. An examination of the economic effects of past regulatory actions would shed light on the extent to which this hypothesis is true.

The development of this research area must be carefully considered prior to implementation.

Groundwater Research

The Nation's groundwater constitutes one of its most valuable natural resources. Groundwater supplies the domestic water needs of 20 of our 100 largest cities and 96 percent of rural America. At least half of the population relies on groundwater for drinking water.

Though the nature of groundwater makes it available in various quantities in most locations, it is subject to contamination from a wide variety of sources, which are also widely distributed. Dealing with such contamination is complicated by the extremely slow movement of pollutants through the subsurface environment. Decades or centuries may pass before groundwater quality can be naturally restored after contamination.

Our scientific, engineering, and economic goals should thus be primarily directed toward the protection of groundwater quality rather than its restoration. Protection of the groundwater resource must be based on understanding the subsurface as a pollutant receptor and on systematic development of information concerning the transportation and transformation of pollutants in both the unsaturated and saturated subsurface environments. The development of sampling technology, analytical methodology, and contaminant indicators is prerequisite to definitive groundwater studies.

EPA recently announced the expansion of its groundwater research program in Ada, Oklahoma. The prime objective of this internal program is the development of source control criteria documents to support regulatory needs. The complexity and size of the problem are such, however, that complementary longer-term efforts are required to stimulate the near-term program and strengthen its scientific foundations. Close coordination with the U.S. Geological Survey is also required.

Fundamental Mechanisms Involved in Land Application of Wastes

In order to take better advantage of the opportunities for land applications, more information is needed on a number of processes. We must be prepared to answer questions such as: (1) What are the long-term impacts of waste materials on soils, surface waters, and groundwaters? and, (2) What are the potential health threats?

A fundamental understanding of the transport, transformation, and fate of materials in waste is essential if we are to adopt these practices on a large scale. Materials that need investigation are heavy metals, organic compounds, other toxic substances, and nutrients. Studies are needed to determine the fate of organics in soils, formulations of degradation products, effects on soil structure and vegetation, movement through the soil profile, and changes in those compounds as a result of chemical, physical, and biological activity of the soil systems. The interactions of metals and other toxics in soils require similar investigations. Also needed are new approaches for detoxification effluents from publicly-owned waste treatment works and new definitions of critical parameters that identify and characterize degrees of toxicity.

Finally, problems associated with the management of nutrients, (particularly nitrogen and phosphorous) must be resolved. A primary objective is to manage soil treatment systems so that nutrients are both utilized and prevented from entering groundwater and surface water in harmful concentration.

The need for health information related to land application practices is equally important. These needs center on information related to (1) uptake and effects of metals, organics, and other toxic substances on food chain and man, and (2) viruses, parasites and bacteria that may enter groundwater systems. (This area is an important segment of groundwater research as well.) Some food chain studies are being undertaken, but to date these have been limited to only a few food, soil, and pollutant combinations.

Chemical and Physical Methods of Measurement

Programs to control and abate environmental pollution are critically dependent on the ability to identify and measure substances in the environment. As obvious forms of pollution are brought under control, concern is turning toward the more ubiquitous pollutants present in the environment at low concentrations. This concern has become particularly acute as the potential link between pollution and cancer increases and as other more subtle and far-reaching effects are investigated. These concerns have presented the measurement method scientists with some severe challenges:

- Methods are now required to qualitatively and quantitatively measure environmental pollutants present in a background of great variety. The methods must provide reasonably accurate measurements at concentrations as low as the part-per-trillion level.

- Methods must be made available for the analyzing of soils, sediments, particulate matter, and tissues. All of which present problems significantly different from the analysis of air and water samples.

- Methods must be translated into low-cost, reliable devices for unattended deployment at remote sites. Widespread use of such devices is necessary in progams requiring continuous surveillance and monitoring.

To meet these challenges, basic studies are needed to accomplish the following goals:

1. Physical and chemical properties should be determined for substances that might lead to more selective and sensitive analytical methods. Studies should also be carried out to provide the basis for the measuring instruments needed for unattended use in monitoring activities.

2. Sampling methods should be improved to provide for the efficient sampling of classes of compounds and the selective sampling of specific compounds. Success in this area would allow analytical methods to be more readily applicable to the identified measurement requirements.

3. Our understanding should be improved about the mechanisms that govern the quantitative analysis of substances adsorbed to or interspersed in solid materials.

4. Quality control should be provided for all aspects of environmental measurement.

Global Problems

Formulation of many regulatory strategies within the United States requires knowledge about worldwide background levels, sources of manmade and natural pollutants, and movements and transformations of pollutants. In most instances, relatively little is known about what constitutes natural pollutant levels, whether pollutants are increasing or decreasing, or whether controls within the United States will substantially affect world levels in light of continuing emissions from natural or industrial sources in other countries. Impacts of specific activities or trends in other countries, (deforestation, for example) on U.S. environmental efforts remain largely unknown.

EPA activities in this area are primarily oriented toward supporting United Nations programs. Global trend and impact analyses within the United States are not conducted in a systematic manner. Efforts to develop and store data to support such analyses are equally scattered. Recently, lead, DDT, transuranic materials, carbon dioxide, freons, mercury, and petroleum hydrocarbons have emerged as pollutants with worldwide implications. But in each case, only limited information has been available, and each analyti-

cal team has had to develop its own methdology to obtain and analyze data. A focal point for U.S. efforts would simplify this task. The principal mission of such an activity could include methodologies for analyzing global problems and for collecting and storing data on pollution sources and trends.

Ecosystem Dynamics

Our present knowledge of ecosystem dynamics is mostly descriptive. Our capacity to quantify changes is limited, and our ability to predict effects is even less certain. However, some simple ecological principles are being used to manage the agriculture, aquaculture, and silviculture industries, even though the governing ecological principles are only partly understood. These management practices have been perfected mainly through trial and error. Management of the more complicated natural ecosystems will require greatly increased knowledge of the limiting parameters of their structure, function, and dynamics.

To develop this knowledge, long-term studies on the structure of ecosystems under stressed and unstressed conditions should be conducted, and the abiotic and biotic components that structure the system should be described.

Investigations of the functions and dynamics of ecosystems are required to define the adaptive and variable characteristics of the normal systems. Results can then be used to quantify the responses of selected ecosystems to stress perturbations and determine their reversibility. Ecosystem responses include changes in species composition and the reduction of community-level functions, including decreased productivity, simplified structures, and decreased species diversity.

Information from such studies is not developed in a short period of time. Sustained support for dedicated professionals is necessary to assure that long-term objectives are achieved.

Pollution Control Processes

The development and adoption of new pollution control technology is a complex process. The private sector has an important role to play in fostering and developing new processes. Advances may begin with the identification of a generic concept--electrostatic separation, flocculation, chemical reaction, or biological digestion for example. From the initial concept, development proceeds through various laboratory, pilot-, and full-scale experimentations and demonstrations until a reliable form of the technology is established. As the concept matures, the number of applications may increase, and with it, the number of specific technical problems that must be solved.

EPA's control technology research, development, and demonstration program has in the past been involved in the full range of activities associated with developing new control options. Near term applied and development activities have received the highest priority. The efficiency of the program (i.e., the

number of problems solved with a special level of resources) is controlled by two aspects of the quality of the research. The first is engineering innovation or the ability to invent or find new concepts for removing pollutants. The second is the sophistication of the researcher in understanding the basic science (i.e. physics or chemistry) of the technical problems impeding successful demonstration of a technology.

Many of the problems in separation or pollution control can be assessed from the point of view of their basic physics and chemistry. To sustain applied activities, exploratory studies are needed to advance basic understanding of the mechanisms that limit our ability to reduce, recover, and/or reuse pollutants. Studies of advanced separation and concentration techniques are needed to improve the treatability of wastes. Research efforts should first include principles in separation and concentration techniques such as activated carbon, reverse osmosis, etc. Also, innovative detoxification methods that reduce environmental impacts of residuals should be assessed.

The applied nature of the past efforts has not provided the opportunity for research that would underpin the present state of the art or catalyze the scientific community to consider conceptually new control concepts and waste management options. Because regulatory incentives for advancing the knowledge are at best limited, the technology reservoir is running dry.

The state of the art for pollution control has become increasingly sophisticated as the push increases for higher efficiency and pollution-specific effectiveness. The ability to adapt known treatment techniques to varying uses is hampered, however, by a lack of understanding of the basic chemical, biological, and physical processes that govern the treatment process. This research problem is a candidate for longer-term exploratory research and can influence the general applicability of available technology.

Multimedia (i.e. air, water and land) pollution control is a management option with potential for economic and technological benefit. Since the EPA regulatory mandates promote individual media control programs, the opportunities to exploit combined control at any one point source site (i.e. industrial, municipal) are limited. Research to identify and characterize these multimedia opportunities should be conducted on a limited basis to provide feasibility criteria for influencing the future direction of Agency regulatory programs. The increasing complexity of pollutant control will likely require future consideration of more innovative waste management alternatives such as combined and multimedia environmental control.

Screening Techniques and Early Indicators of Toxicity

Passage of the Toxic Substance Control Act has created significant demands (1) for techniques to screen new chemicals and (2) for information that relates easily recognized disease to more subtle physiological effects. The first area requires reproducible, sensitive, and rapid tests that can

be used to assess the potential toxicity of the many chemicals, compounds, and mixtures that are entering the environment. In this area, exploratory research is needed to find new and or improved ways to screen for human/ecological effects. Scientific criteria that link toxicological effects with measurable reactions must be provided so that screening methodologies can subsequently be developed for regulatory or research use.

In the second area of physiological effects, improved understanding of the physiological, biochemical, and pathological processes associated with toxicity is required to relate sublethal effects identified in early-stage testing with longer-term studies. From this information, models can be developed that reduce the need for using long-term, full-duration exposure studies as the primary assessment tool.

The development of new chemicals is not likely to abate in the future. The corresponding need to develop screening techniques and improve the understanding of toxic effects will not be easily accomplished. This kind of research requires the slow building and extension of existing scientific knowledge as well as long-term, stable resource commitments.

Atmospheric Processes and Effects

Atmospheric processes and effects research provides information that relates to several important EPA needs. It is particularly important because potentially large social impacts could occur as efforts to prevent significant air quality deterioation were forward. This type of research provides information on the link between air pollution sources and receptors, and on atmospheric effects such as visibility degradation. Mathematical models incorporating transportation and transformation terms of atmospheric processes are an important end product of this research. Individual tasks include theoretical and basic experiments in photochemistry, laboratory simulations of atmospheric processes in smog chambers and wind tunnels, and rather large field experiments involving a number of investigators.

Information from these studies contributes to the resolution of many environmental problems: Visibility deterioration, Influence of halocarbons such as the aerosol propellant freons on lower atmosphere photochemistry and stratospheric ozone, Greenhouse effect of CO_2, Natural air pollutants, Self cleansing of the atmosphere, Air pollutant transport across state and national boundaries, Transfer of air pollutants to soil and water by both dry and wet deposition, Transfer of pollutants in water to air by volatilization or aerosolization, Transport and lifetimes of toxic substances (including carcinogens) in the air, Formation of toxic substances in the air by photochemical or nonphotochemical atmospheric reactions, Effect of air pollution on climate and weather, Effect of complex terrain on ground level air pollutant concentrations, Transport and transformations of pollutants from diesel-powered vehicles in the vicinity of high traffic density roadways, Transport and transformation of pollutants emitted to the air by new energy technologies.

Development of Risk Assessment Methodologies

Risk assessments are an essential component of all regulatory decisions. These assessments must follow the development of information on exposures and toxicity, and they involve a mixture of statistical, scientific, and public policy considerations. In some instances, the benefits conferred by a suspected substance, process, or facility can be achieved by alternatives, in which case the regulatory decision may be clear-cut. In many other cases, important benefits may be lost, and the size of the risk must be balanced against the benefits. Insufficient data is a common deficiency that plagues almost all assessments, but the development of methodologies to properly assess risks may represent a more formidable and complex problem.

Recently, the need to make assessments regarding carcinogenic substances in food, water, and air has focused attention on assessment procedures. A determiation of acceptable daily intakes of potentially carcinogenic substances is an important part of this procedure. The methodologies for making this determination have been reviewed in the literature. Interest in carcinogenic risk has aroused attention, but environmental assessments are much broader, and the need for improved methodologies is much more pervasive. Improved risk assessment methodologies are required to assure that proper balances are achieved and over protection does not become a common approach.

7. LABORATORY MECHANISMS USED BY OTHER AGENCIES

Many mechanisms exist to ensure that long-term research is conducted. To determine which mechanism is most appropriate for EPA, we first performed an extensive review of past studies that had evaluated the effectiveness of (1) intramural laboratories, (2) individual grants and contracts, (3) University Centers and, (4) Government-owned, contract operated research centers (GOCO's). Though the literature provides some insights into each mechanism's function, it does not suggest that any mechanism should be initially rejected. Instead, it was determined that the viability of a particular mechanism for long-term research depends on the unique set of circumstances governing the operations of the sponsoring organization. From this point, in-depth interviews were conducted with approximately 90 key people in the following 20 organizations:

- National Cancer Institute
- National Heart, Lung, and Blood Institute
- National Institute of Environmental Health Sciences
- National Oceanic and Atmospheric Administration
- Department of Agriculture:
  - Cooperative State Research Service
  - Agricultural Research Service
- Occupational Safety and Health Administration
- National Aeronautics and Space Administration
- Department of Defense (Navy)
- Food and Drug Administration
- National Science Foundation
- Department of Energy
- Electric Power Research Institute
- Universities:
  - California-Davis
  - Rhode Island
  - Wyoming
  - Oregon State
- Johns Hopkins Applied Physics Laboratory
- Battelle Northwest Laboratories
- Oakridge National Laboratories

Organizations were selected to include a wide variety of activities and organizational forms. Organizations devoted to basic research, combinations of basic and applied research, and development of engineering methodology were included. Sizes ranged from a one-office operation to multi-million dollar facilities. Institutional settings ranged from universities to private corporations. Interviews were conducted with organization directors, middle managers and bench scientists.

The agencies contacted used combinations of intramural laboratories, GOCO's, university centers, or individual grants and contracts. All of the agencies attempted to select the best mechanism for a particular type of work, and all recognized the interrelationship between basic, fundamental or anticipatory research and research of a more applied nature.

One of the better statements on the relationship between basic and applied research comes from a recent report of the Director of the National Science Foundation (see Section 9, Bibliography, Item number 22).

The interaction of basic and applied research gives us insight into the nature of technological innovation. It strikes me that we are dealing with a sort of intellectual riverine system. As the flow of ideas nears its terminus, it is a forceful and purposeful thing. We cannot, however, overlook the fact that this great river must rise in thousands and tens of thousands of creeks and brooks at the higher elevations and remotest limits of its drainage basin. It is the myriad contributions of the latter that give the river its ultimate force and, quite simply, this is why we must nurture the earliest sources if we are to safeguard the creative force of the entire process.

Intramural Laboratories

Federal agencies that have inhouse laboratories have confidence in them. It is there that the few Nobel laureates within the Federal government work, and it is there that future research managers develop. Most studies emphasize the need for an intramural capability. The Report to the President on Government Contracting for Research and Development, Bureau of the Budget (McNamara Report), [see Section 9, Bibliography, Item number 17] states that:

> "The management and control of the Federal research and development effort must be firmly in the hands of full-time Government officials clearly responsible to the President and the Congress.
>
> Subject to this principle, many kinds of arrangements—including both direct Federal operations and the various patterns of contracting and granting now in use—can and should be used to mobilize the talent and facilities needed to carry out the Federal research and development effort. Not all arrangements, however, are equally suitable for all purposes and under all circumstances and discriminating choices must be made among them by the Government agencies having research and development responsibilities."

The Department of Defense Laboratory Utilization Study of April 1975, Office of the Director of Defense Research and Engineering (see Section 9, Bibliography, Item 5) had the following reference:

> "This study found, as did the Service studies, that there is a vital role for the (intramural) laboratories not satisfactorily available from other sources such as industry, universities, FCRC's, Headquarters staffs, Systems Commands, etc. The combination of attributes possessed by the laboratories qualified them to play a unique and needed role in the military planning function, especially to the planning of systems development acquisition and usage and the planning of the Technology Base program to support future systems development. Laboratories also help the services to be "smart buyers" by providing technical advice and supervision to the services interaction with industry, by providing an alternative source of technology so that their existence serves as a source of stimuli to industry to perform well, and by providing centers of excellence in areas of little or no industrial interest."

Several advantages and disadvantages of intramural laboratories were identified during the interviews. Primary advantages were that they:

—provide a continuing center of expertise related to the agency's mission

—have the ability to guide or monitor work done by grant or contract

—can manage major developmental activities.

Disadvantages are that they:

—are difficult to change concerning personnel because of civil service regulations

—lack flexibility in changing mission

—have ceilings on government salaries that slow recruitment at top levels.

Extramural Mechanisms

Agencies and Congress, through its legislative initiatives, have provided a number of methods for conducting research and development. Most agencies have settled on variations of individual grants, university centers, contracts, and GOCO's. Parts of some agencies clearly separate the intramural research staff from grant and contract activities, but most combine the activities in varying degrees. A brief description of the extramural mechanisms follows.

Individual Grants and Small Contracts

As can be determined, all agencies use the individual grant and contract mechanism to further their research. Individual grants and contracts are characterized by their size and method of selection for funding. Grant applications usually represent the ideas of an individual and are evaluated through a peer review system which includes reviewers from outside government. Contracts are defined by scopes of work developed through various methods by the agencies and usually are evaluated by agency personnel.

Grants and small contracts have the advantage of utilizing the talents of individuals or small groups outside government to meet national research needs. The work is usually disciplinary in nature and directed toward results amenable to the disciplinary approach.

Other advantages are:

- The scientific approach can be excellent if the grants are carefully selected
- There is no long-term Agency commitment
- The investment is relatively small
- The small grants may be the only mechanism to support the ideas of an individual; and this opportunity may be unique
- Individual grants are relatively easy to end though the judgement to end them may be difficult.

The disadvantages of the individual grants or small contracts are that it is sometimes difficult to build a cohesive program through this mechanism alone and it is sometimes difficult to mount an interdisciplinary effort.

In summary, the individual grants and small contracts represent the creeks and brooks of the riverine system, but they do not necessarily result in an organized river system.

University/Institutional Centers

Agencies can choose broadly based, multidisciplinary university centers covering a considerable part of the agency's interest, or they can select centers to deal with specific areas of research to supple ment the government laboratory's capability. Indeed, some agencies have chosen both paths. The essential ingredient for a center is a firm base within a university or institution that has a common interest in the public

need as perceived by the agency. This common interest must be shared by leaders within the institution and the agency. Efforts on the part of the Federal establishment to create excellence within an academic institution in the absence of a strong leader and firm institutional base have been unsuccessful. Infusions of money into such institutions have also failed.

Once the common interest is established, there are many choices. The agency can support centers broadly oriented to many of its interests or targeted to specific purposes. The agency can either support a core group with salaries, equipment, and facilities and require the center to gain any additional support through individual grants and contracts, or it can support most of the cost of the center. The cost of a center ranges from $100,000 to $1.5 million per year.

University centers are widely used by the National Institutes of Health, National Institutes of Environmental Health and Safety, National Oceanographic and Atmospheric Administration's Sea Grant Program; and other agencies are beginning to use this mechanism. The centers can vary in size from one supported center director to a laboratory employing one to two hundred people. Many centers established by one agency now receive support from several others. In such cases, the agencies providing secondary support have been able to capitalize on the talent pool created by the foresight of the original sponsor. Advantages of university centers are that they:

--are sources of high quality science

--can mount a multidisciplinary effort

--provide talent not available to the agencies elsewhere

--may not require extensive facilities

--may be dedicated to an agency mission

--are within reasonable cost ($500,000 to $1.5 million a year)

Disadvantages are that they:

--may sit uncomfortably within a discipline-oriented academic institution

--depend strongly on center director for success

--take time to establish

--can cause conflict with individual researchers' teaching function

--may be difficult to redirect or terminate.

Government-Owned, Contractor-Operated Centers (GOCO)

GOCO institutions date back to 1936, when they were formed in quick response to Federal needs in areas where the Federal laboratory capability was thought to be insufficient and where no single university source was able to meet the needs.

GOCO's are useful in situations where research goals demand large, integrated programs of long duration, where the work may be sensitive or unique (skills not otherwise available), and where interdisciplinary studies predominate.

GOCO's and Federal contract research centers (FCRC's) (facilities furnished by contractor) have similar characteristics. The centers are established to address a requirement that is not met by existing Federal laboratories or a possible consortium of universities. The money requirements are substantial--$50 to $150 million or more--and the contract time can vary from 1 to 5 years. The Government may or may not own the facilties. The Center may derive all of its money from one agency (or part of an agency), or it may seek funds from any source. An agency may support a small part of a center, or it may make a substantial and continuing investment in such a center.

Federal contract research centers have been started for a variety of reasons. The Johns Hopkins Applied Physics Laboratory, for example, was founded to deal with the problems of faulty artillery shells in World War II. The AMES Laboratory tested aircraft during the same period. Functions of both laboratories have changed and expanded over the years.

In the past 40 years, the use of FCRC's and GOCO's has spread throughout the Federal establishment. In an Office of Management and Budget draft Circular on Research and Development Acquisitions, it is recommended that: (a) sufficient intramural skills be present in the sponsor agency to determine whether it is appropriate to give a specific piece of work to the FCRC, (b) effectiveness, efficiency, and work output of an FCRC be evaluated, (c) an effective program for cost control be established, and (d) a periodic review of the FCRC's operation be provided.

The advantages of FCRC's and GOCO's are that they:

—can bring together resources not available elsewhere to address a problem area

—can move projects from a basic research effort into practice

—are large enough to provide multidisciplinary staff.

The disadvantages are that they:

—require a large investment to support (2000 to 3000 people) personnel and facilities. (For example, a major FCRC or GOCO would require more money and staff than EPA now has for its entire research program)

—are difficult to terminate and may be slow to change direction or mission

—need a clearly described and firmly controlled mission (both in scope and duration) to provide a basis for proper management

—need strong financial management

—may move toward self-perpetuation and survival, which reduces flexibility.

Within the organizations contacted, the Electric Power Research Institute stands out as an example of a sizable institution not funded by the Federal government. The institute conducts activities that range from basic research to large development projects on a budget of approximately $190 million funded by the electric power industry. The present staff totals 350 technical and 150 support personnel. The relative newness of the institute (1973) provides some important insight. At the time it was established, the institute recognized that it wanted to develop information quickly. It elected to use outside contracts of varying sizes as the principal mechanism for conducting its research activities. The institute did not establish an internal laboratory, but rather hired a cadre of senior professionals to manage its program. Considerable flexibility to recruit and pay for this senior team was essential to its success, and the utilization of existing organizations was important to a rapid start.

General

The essential ingredients in selection of an extramural research mechanism appear to be as follow:

1. The agency must articulate its goals,

2. The agency must examine those goals and decide that meeting them requires the assistance of institutions outside government,

3. The agency must consider the merits of individual grants, university centers, GOCO's and FCRC's

4. The Agency must select the mechanism(s) and institutions thought to match their own goals most closely.

8. OPTIONS FOR CONDUCTING EXPLORATORY RESEARCH

The analysis thus far has revealed a number of directions in which EPA could channel it exploratory research efforts. This chapter presents the generic options that the task force considered in arriving at its major conclusions and recommendations. Specifically, there are four options for exploratory research that must be carefully examined. These are:

1. Separation or integration of exploratory research and regulatory/operational support R&D;

2. Separation or integration of intramural and extramural exploratory research activities;

3. Use of the existing laboratory network or consolidation into "super labs" for conducting exploratory research; and finally

4. Continued use of existing mechanisms or development of new mechanisms for the performance of extramural exploratory research.

This chapter will explore these four options while taking into consideration the following factors:

- The past experience of ORD/EPA in planning, implementing, and reviewing environmental research

- The experience of other Federal agencies engaged in exploratory research through use of contract laboratories

- The experience of other Federal agencies in establishing independent research centers within universities

- The advantages and disadvantages of existing FCRC's, university centers and individual contract/grant programs

- The management approach necessary for each of the above research mechanisms

- The environmental research most suitable for each type of research laboratory.

Separation or Integration of Exploratory Research and Regulatory/Operational Support R&D

As shown earlier, approximately 30% of all EPA research and development funds are currently devoted to exploratory research. All ORD laboratories conduct various levels of both exploratory research and regulatory/operational support R&D. Currently, no administrative or program differentiations exist between these two types of research, which are integrated at the laboratory level. Our investigations have shown that within most other Federal agencies, basic, applied, and development activities are commonly located together at the laboratory level. However, some agencies have created administrative mechanisms to separate these research areas. Examples include the Department of the Navy, which has a six-point budget wherein basic and exploratory activities are two elements, and the Department of Energy, which recently established a separate Office of Research to direct more fundamental activities. Some laboratories were found to separate basic research from more applied research. Within the large contract research laboratories visited by the task force, two of five had a separate division devoted entirely to basic research. It should also be recognized that nationally a pseudo separation occurs between exploratory and applied research because a large portion of U.S. exploratory research is being conducted by academic institutions.

Since both the separation and integration approaches appear to be viable methods of conducting exploratory research, the task force examined both approaches. If ORD were to separate these functions at the laboratory level into a dual laboratory system, some of the major advantages might be as follows:

1. It would be easier to isolate researchers from the quick-response needs that so often accompany regulatory/operational support research and development and assure a stable atmosphere.

2. The exploratory research would have more organizational visibility, which would demand increased accountability.

3. Bottom-up planning for exploratory research would be facilitated.

The major advantages of continued integration of exploratory efforts with more applied efforts are as follows:

1. Better control could be exercised over research projects that involve aspects of both exploratory and applied research.

2. A strong synergism would continue to occur between the two types of research.

3. No significant organizational changes or personnel transfers would be required.

The advantages of continued integration at the laboratory level appear to outweigh the advantages of separation into a dual laboratory network. However, the task force does feel that it is warranted to have exploratory research separated administratively from regulatory/operational support R&D. The functional separation of these two activities would weaken existing efforts. In particular, the isolation of exploratory activities into a number of separate or super-labs is not warranted because exploratory scientists would then be insulated from their regulatory/operational support R&D peers at other locations. Such an arrangements would be both financially and scientifically expensive. Both types of scientists need to be able to communicate on a regular basis to enhance each others' approaches. The exploratory research could be planned, implemented, and reviewed by ORD. The regulatory/operational support R&D could be planned and reviewed by both ORD and the program offices and for the most part implemented by ORD.

Separation or Integration of Intramural and Extramural Exploratory Research Activities

Within EPA's predecessor agencies, extramural research activities were often managed separately from intramural research programs. After EPA was formed, extramural and intramural activities were integrated and managed as a total program aimed at achieving a particular objective. For the most part, this integration into a total program has been successful in EPA. The extramural activities are considered to be extensions of intramural efforts, and they are aimed at filling information gaps not easily satisfied by intramural researchers. The success of this approach depends on having an adequate, well qualified intramural staff to plan, develop, and review extramural activities. The staff must do an effective job of managing the extramural program and must also act as an information transfer link through which new information flows into the Agency.

Our interviews have shown that independent extramural programs are being conducted successfully in isolation from intramural programs by a number of organizations (e.g., the National Science Foundation). The primary reason for the success of either method lies in the purpose and the nature of the research programs. The purpose of EPA's overall research effort is to develop information to support regulations, whereas the National Science Foundation's overall objective is to develop basic scientific knowledge. The former type of research requires directed and integrated intramural and extramural activities to achieve the regulatory objectives of EPA. The latter activity, on the other hand, is not always directed toward specific application objectives.

The Task Force believes that it is appropriate for EPA to integrate the intramural and extramural research activities conducted in support of regulations. These shorter-term activities must be closely managed and directed toward filling information gaps for regulatory purposes. The Task Force also believes that this arrangement should apply to exploratory efforts to assure the transfer of research results. But, because these activities will focus on longer-term objectives, a greater degree of freedom in the management of extramural projects is possible, and scientist to scientist

contact between EPA and the academic community should be an important means of assuring that coordination is achieved. Closer coordination of projects funded by other agencies should also be established.

Geographical Consolidation of Intramural Exploratory Research Laboratories

The 15 existing EPA laboratories are located in nine different geographical sections of the United States. Another mode of operation for this laboratory system would be to physically locate all intramural research at one or more laboratories dedicated solely to exploratory research. (For example, to minimize the movements of people, one lab could be at Cincinnati, one at Research Triangle Park, and one at another location). Though one can argue that this arrangement would increase synergism among the various media and discipline-oriented exploratory scientists, it would have the following disadvantages:

1. Programs and researchers not currently located at the three selected laboratories would have to be moved at significant costs and delays in research outputs.

2. A separation would be created between exploratory research and regulatory/operational support R&D.

3. A duplication of some personnel, facilities, and equipment would occur in the separation of exploratory and regulatory laboratories.

Unless a broad new exploratory research area not currently addressed by the existing ORD laboratory network is identified, the present laboratory system appears to be a satisfactory method for conducting research in EPA.

Extramural Exploratory Research Options

EPA currently employs three mechanisms for its extramural research activities. The Agency conducts most of its extramural research through contracts and grants to universities, private institutions, and other Federal laboratories. EPA does not have its own contract laboratories* (such as the National Laboratories of the Department of Energy) or any centers within universities (such as those sponsored by the National Insitutes of Health). However, EPA does utilize the National Laboratories to conduct individual projects through passthrough funds and by the Interagency Agreements (IAG) mechanism. These cooperative interagency approachs should be expanded for exploratory research. Recently, another mechanism known as mission contracts has been encouraged within EPA because of the limited contract management personnel needed to administer numerous small projects.

*EPA does provide support along with the Food and Drug Administration for the National Center for Toxicological Research.

Traditionally, EPA relied on these mechanisms because they were proven adequate to meet Agency needs for producing information, primarily in support of regulations. But, exploratory activities require a stable atmosphere, top quality scientists with long-term professional commitments, and good facilities. Exploratory research must also be administratively isolated as much as possible from the day-to-day pressures of the regulatory programs. The individual grant is therefore a good mechanism for supporting talented scientists working on specific exploratory research problems. The Task Force recommends that individual grantees continue to be utilized as one approach to conducting this type of research. Individual grants allow scientifically diverse and geographically separate innovative researchers to contribute to the national environmental effort.

Other exploratory activities associated with the research areas identified in Section 6 require a larger research team than available through a single grantee. To conduct programs of this magnitude, other Agencies have traditionally used either FCRC's or institutionally based centers. If we consider the development of either of these two mechanisms within the framework of EPA, the following observations can be made about the FCRC mechanism and scientific centers.

First, an environmental FCRC would:

--require $100,000 to $150,000 to operate (this would necessitate a 40-to 60 percent increase in ORD's budget);

--require 2 to 5 years to become operational because of staffing and facility requirements;

--to some extent deplete the professional staffs of many existing Federal, university and private labs;

--require an increase in EPA management and administrative personnel;

--duplicate many facilities now in existence.

--delay efforts aimed at allowing EPA to expand utilization of large centers such as those operated by they Department of Energy.

Second, a system of centers located in universities and other institutions would:

--enable EPA to take advantage of existing research groups throughout the country;

--be compatible with the size of EPA's present programs;

--be implemented quickly because only moderate staff increases would be required and no large facilities other than equipment would be needed;

—be able to target one specific problem rather than a broad number of problems and managed with relative ease;

—be implemented at a reasonable cost of between $500,000 to $1 million per year for each center.

The Task Force therefore recommends that institutionally based centers be used if EPA significantly expands its extramural exploratory research program into any of the areas identifed in Section 5.

In summary, this analysis has lead the task force to the following conclusions:

- Exploratory research and regulatory/operational support R&D should continue to be linked at the laboratory level.

- The present EPA laboratory system should not be reorganized into a few super exploratory laboratories and other laboratories directed to regulatory/ operational support R&D.

- Intramural and extramural exploratory programs must utilize scientist-to-scientist contacts to assure that research conducted by these two mechanisms remains integrated.

- Small centers dedicated to specific research problems are the best mechanism within EPA's framework to supplement exploratory research. (Such small centers would match the nature and size of the problems needing to be addressed at this time.) Five to ten such centers should be established.

- A large Federal Contract Research Center for long-term activities should not be established at this time.

- The problems associated with protecting man from substances contained in water, air, and food are expanding rapidly. In the long-term, a significantly larger and different institutional mechanism may be warranted to match this evolving need. These requirements should be monitored and re-evaluted in the future.

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10. APPENDICES

Appendix A. Office of Research and Development Program Structure

The Office of Research and Development functions as the principal scientific component of EPA under the direction of one of the six assistant administrators of the Agency. Its fundamental role is to produce scientific data and technical tools on which to base sound national policy in the development of effective pollution control strategies and reasonable environmental standards. ORD seeks to answer the following questions:

- How can pollution be identified, measured, and monitored?
- What are the relationships between pollutant discharges and environmental degradation?
- What levels of pollutant discharge from specific sources can be permitted while still attaining defined ambient quality standards?
- What are the health and ecological effects of pollutants on people, other life forms, and the inanimate environment?
- What technologies are available for controlling pollution and what are their characteristics?
- How can environmental quality best be maintained and improved?

The Office of Research and Development Program is carried out by about 1,700 employees with a current budget of $250 million per year. The Office staff is composed of professionals in 60 disciplines located throughout the Nation in 15 major laboratories and one headquarters office. All personnel, scientists, and engineers contribute to a research program that consists of inhouse activities as well as programs shared with the academic community, the private sector, and numerous Federal, State, and local agencies. The organization of ORD is presented in Figure A-1 .

EPA's research program is multidisciplinary and multimedia in nature. For purposes of budgetary authorization and appropriation, programs are classified along media and/or categorical lines as follows:

- Air
- Water Quality
- Solid Waste
- Pesticides
- Radiation
- Water Supply
- Toxic Substances
- Energy Research

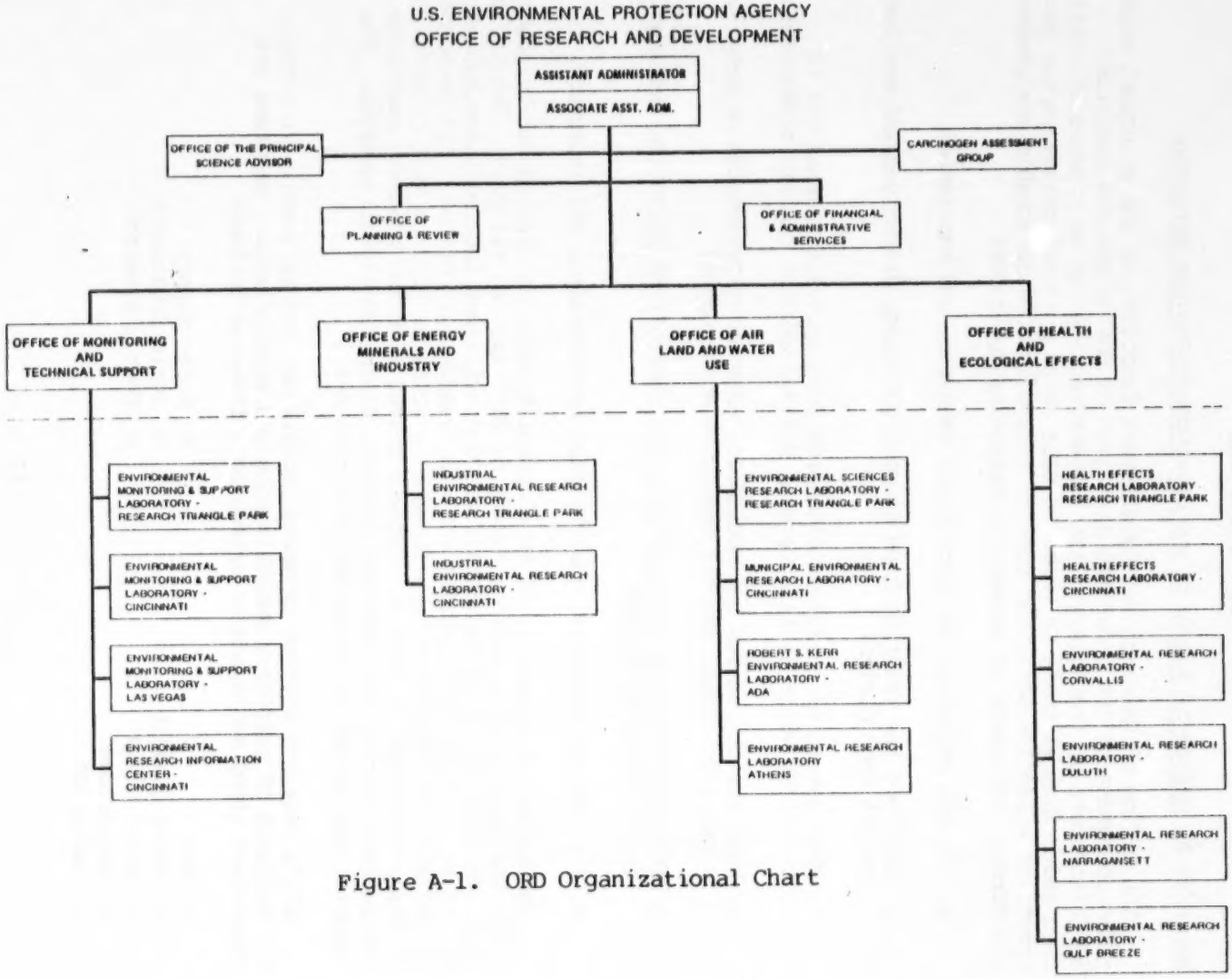
U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RESEARCH AND DEVELOPMENT
ASSISTANT ADMINISTRATOR
ASSOCIATE ASST. ADM.
OFFICE OF THE PRINCIPAL SCIENCE ADVISOR
CARCINOGEN ASSESSMENT GROUP
OFFICE OF PLANNING & REVIEW
OFFICE OF FINANCIAL & ADMINISTRATIVE SERVICES
OFFICE OF MONITORING AND TECHNICAL SUPPORT
OFFICE OF ENERGY MINERALS AND INDUSTRY
OFFICE OF AIR LAND AND WATER USE
OFFICE OF HEALTH AND ECOLOGICAL EFFECTS
ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - RESEARCH TRIANGLE PARK
ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - CINCINNATI
ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS
ENVIRONMENTAL RESEARCH INFORMATION CENTER - CINCINNATI
INDUSTRIAL ENVIRONMENTAL RESEARCH LABORATORY - RESEARCH TRIANGLE PARK
INDUSTRIAL ENVIRONMENTAL RESEARCH LABORATORY - CINCINNATI
ENVIRONMENTAL SCIENCES RESEARCH LABORATORY - RESEARCH TRIANGLE PARK
MUNICIPAL ENVIRONMENTAL RESEARCH LABORATORY - CINCINNATI
ROBERT S. KERR ENVIRONMENTAL RESEARCH LABORATORY - ADA
ENVIRONMENTAL RESEARCH LABORATORY ATHENS
HEALTH EFFECTS RESEARCH LABORATORY RESEARCH TRIANGLE PARK
HEALTH EFFECTS RESEARCH LABORATORY - CINCINNATI
ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS
ENVIRONMENTAL RESEARCH LABORATORY - DULUTH
ENVIRONMENTAL RESEARCH LABORATORY - NARRAGANSETT
ENVIRONMENTAL RESEARCH LABORATORY - GULF BREEZE

Figure A-1. ORD Organizational Chart

However, pollution problems often have broad impacts. For example, various control systems for air pollution emissions may produce residual that become solid waste or water pollution problems. Therefore, ORD is structured and operates along parafunctional lines (i.e., research to determine the health effects of exposure to pollutants is grouped in one program area). The ORD research program is made up of the following components:

Health effects research assesses health hazards resulting from environmental pollution in several media and/or categories including air, water, pesticides, radiation, water supply, and toxics. Research problems are classified according to exposure levels, perceived effects, and the need to take regulatory actions to protect man.

Ecological processes effects research focuses on determining the effects of atmospheric, aquatic, and terrestrial pollutants on the structure and function of ecosystems and their biotic and abiotic subcomponents.

Transport and fate of pollutants research examines the biological, chemical, and physical phenomena affecting pollutants as they migrate from source to receptor and otherwise transform and persist in the ambient environment. Empirical and analytical techniques are developed that relate atmospheric/aquatic/terrestrial pollution to sources and receptors.

Minerals, processing, and manufacturing research addresses point sources of pollution from industrial sectors, especially those from mining, manufacturing, service, and trade industries that extract, produce, and process nonenergy materials into consumer products. Methods to control and prevent environmental degradation resulting from accidental spills of selected materials are also researched.

Renewable resources research encompasses development of total management systems to control air, water, and land pollution resulting from the production and harvesting of food and fiber and their related residual wastes. Predictive methodologies are developed, and probable trends in production of renewable resources and resulting environmental impacts are assessed. An example is the demonstration of pest management strategies to minimize the usage and runoff of agricultural pesticides.

Waste management research focuses on the prevention, control, treatment, and management of pollution resulting from wastewater discharges from community, residential, or other nonindustrial activities, including urban runoff. Problems associated with the collection, transport, and management of solid wastes are also researched. This subprogram provides technical information to support the Agency's operating program in construction grants, comprehensive water quality planning, and solid and hazardous waste management.

Waste supply research, development, and demonstration activities provide the technology and management criteria necessary to maintain dependably safe surface and groundwater supplies of drinking water. Health effects resulting from contaminants in drinking water are also studied.

Environmental management research develops improved procedures for planning, implementing, enforcing, and assessing cost-effective environmental protection strategies for particular problem areas such as air and water. Institutional, economic, and decisionmaking problems faced by governmental multimedia environmental programs at local, State, and regional levels are analyzed. New management methods for implementing environmental protection plans are evaluated.

Characterization and measurement methods development provides methodologies and measurement instrumentation for all pollutants (pesticides, toxic substances, industrial chemicals, petrochemicals, combustion products, etc.) in air, land, and water (surface and groundwaters). Research deals with the basic physical and chemical parameters of pollutants and development and/or adaptation of instruments to detect and quantify pollutants.

Measurement, techniques, and equipment standardization research provides reference methods, sampling procedures, and monitoring systems so that standardized techniques are available for monitoring the environment.

Quality assurance provides methodologies and criteria for establishing validated measurement systems and conducts quality control activities to assure the intercomparability of all monitoring dasta. This subprogram provides standard reference materials and samples, develops quality control guidelines and manuals, conducts onsite evaluations of analytical laboratories, and makes interlaboratory performance checks to assure that legally defensible data are produced by Agency laboratories.

Technical support is a scientific and technical consultative service provided to other organizations within the Agency to solve immediate and short-term problems through the use of specialized expertise and facilities. The activities typically require analytical measurement or monitoring, but other program expertise is also available.

Technical information research is aimed at managing and coordinating the effective dissemination and transfer of the findings and products of the Research and Development program to users within the Agency and throughout the public and private sectors.

Energy extraction and processing technology covers the characterization of pollutant sources, assessment of environmental problems, and development of control techniques to mitigate the environmental impact of the extraction and raw material processing of energy fuels. Solid, liquid, and gaseous fuels, as well as advanced energy sources such as uranium and goethermal sites are considered.

Energy conservation, utilization, and technology assessment aims to ensure adequate energy production from fossil fuels with minimum damage to environmental quality. Integrated technology assessment activities identify environmentally, economically, and socially acceptable alternatives for meeting national energy demands.

Energy health and ecological effects research determines the environmental effects of energy extraction, transmission, conversion and use so that criteria can be developed in a timely manner to protect human health and the ecosystem. Identification of pollutants released by energy-related industrial operations and determination of their impact on the environment aid in defining the pollution control requirements for energy, producing operations.

Appendix B. Examples of Exploratory Research Advances

1. The Environmental Research Laboratory in Corvallis, Oregon, completed research in 1976 that identified the cause and effect relationships of air supersaturation in Pacific Northwest rivers. Super-saturation or gas bubble disease was killing millions of salmon each year. The results of this research provided information that led to establishment of State standards and development of methods to prevent gas bubble disease. The research staff received the EPA Gold Medal Award for this work.

2. The Environmental Sciences Research Laboratory in Research Triangle Park, North Carolina, initiated research on freons and other halogenated organic air pollutants in the late sixties and early seventies. This action was started as a result of concern for the potential effects that could result from increasing use and release of these materials to the atmosphere. The work was done inhouse and through two research grants. The information developed contributed to our understanding of the problem of stratospheric ozone depletion, which was clearly identified in the mid 1970's.

   Also in the late 1960's and the early 1970's, air pollution researchers recognized that total suspended particulate matter (TSP) was not an adequate air pollution specification. Exploratory research conducted by the Environmental Sciences Research Laboratory, Research Triangle Park, on chemical and physical characterization of suspended particulate matter has produced techniques for size discrimination as well as elemental and compound analysis. The availability of these techniques to investigate problems identified at a later date made it possible to obtain important information on sulfate formation in power plant plumes, on sulfuric acid aerosol emissions from catalyst-equipped vehicles, and on the Denver "brown cloud."

   Dr. Paul Altshuller and other scientists have received numerous awards from scientific societies in recognition of their contributions to the field of atmospheric chemistry.

3. The Environmental Research Laboratory in Athens, Georgia, developed a computer program that uses laboratory data to predict the photochemical transformation rates of organic pollutants in rivers, lakes, and impoundments. Already in use by several laboratories in the United States, Canada, and Europe, the model allows environmental scientists and managers to predict the photochemical behavior of a pollutant without costly and time-consuming field studies of a specific water body.

   Dr. John M. McGuire and Dr. Arthur W. Garrison of the Athen Sciences Research Laboratory received the EPA Silver Medal for their exceptional achievements in demonstrating the applicability of gas chromatography/mass

   Dr. John M. McGuire and Dr. Arthur W. Garrison of the Athens Environmental Sciences Research Laboratory received the EPA Silver Medal for their exceptional achievements in demonstrating the applicability of gas chromatography/mass spectrometry to the identification of specific organic water pollutants, and in developing an economical system for identifying organic pollutants from their mass spectra on a nationwide basis.

4. In the early 1970's, researchers from both the Municipal Environmental Research Laboratory in Cincinnati and the Environmental Research Laboratory in Corvallis, Oregon, tested the widely held hypothesis that removal of a critical nutrient would restore a highly eutrophic lake. In this project, the critical algal growth-promoting nutrient phosphorus was removed by advanced treatment of municipal wastewater while permitting such treated effluent to continue to flow into the lake. The treatment facility at Ely, Minnesota, achieved a discharge with less than 0.05mg/l of phosphorus in the final effluent. This is the only full-scale plant in the world to achieve this low phosphorus residual. The project has increased our understanding of the development of the dynamics of lakes and the factors involved in their restoration.

5. The Solid Waste Research Division in Cincinnati recently developed and tested a new process whereby microwave plasma detoxifies hazardous wastes by decomposition into their elements or into simple compounds. The process was applied successfully at 5 to 7 lb/hr rates in the laboratory to concentrated forms of malathion, PCB's, phenylmercuric acetate, Kepone, and other materials. Currently, a pilot scale verification is underway wherein a 15-kw unit with a 10 to 30 lb/hr capacity for liquids and solids is being built, including all refinements needed for continuous operation.

6. The Water Supply Research Division in Cincinnati, through a number of grants, has developed methods for quantifying virus aggregation and determining its effects on disinfection rates. Virus aggregation or clumping was suspected as being a signficant factor in deviation of virus disinfection results from those expected theoretically. These methods are being used in further research to determine the physical and chemical factors that influence formation and dissolution of viral aggregates. The results of these studies have important implications for other aspects of environmental virology, such as the development of improved virus detection methods and the understanding of disinfection processes.

7. The Industrial Environmental Research Laboratory in Cincinnati has demonstrated the feasibility of using chemical pumping techniques for concentrating metal ions in industrial wastewaters via coupled transport membranes. This new technology uses the phenomenon of chemical pumping whereby metal ions from a dilute solution are transported through a microporous membrane to a concentrated one. The process derives its energy from hydrogen ions flowing through the membrane in the opposite direction. This action is made possible by an organic exchange agent contained within the pores of the membrane, acting as a shuttle. This compound combines with the metal ions on the dilute side, transports the ions through the membrane and exchanges them for hydrogen ions on the concentrated side.

8. The Environmental Monitoring and Support Laboratory in Las Vegas, Nevada, has developed the capability for characterizing plumes by airborne monitoring. This work added the vertical dimension to the traditional ground-based air quality network. The technique was used in four locations at which dispersion of point sources over complex terrain was measured, and at two locations to measure ozone flux from urban areas.

9. The Industrial Environmental Research Laboratory in Research Triangle Park, has undertaken fundamental research in the area of combustion kinetics that has shown that NO_x can be reduced by at least 50 percent by simple combustion modification procedures. This exploratory research effort is continuing and is the keystone to future regulations for the content for NO_x.